Ontario Ministry of Labour

Occupational Health and Safety Division

Health and Safety Support Services Branch

LIBRARY
MAY 2 4 1990
University of Toronto

Occupational Health in Ontario

SCI. MED. DIV.

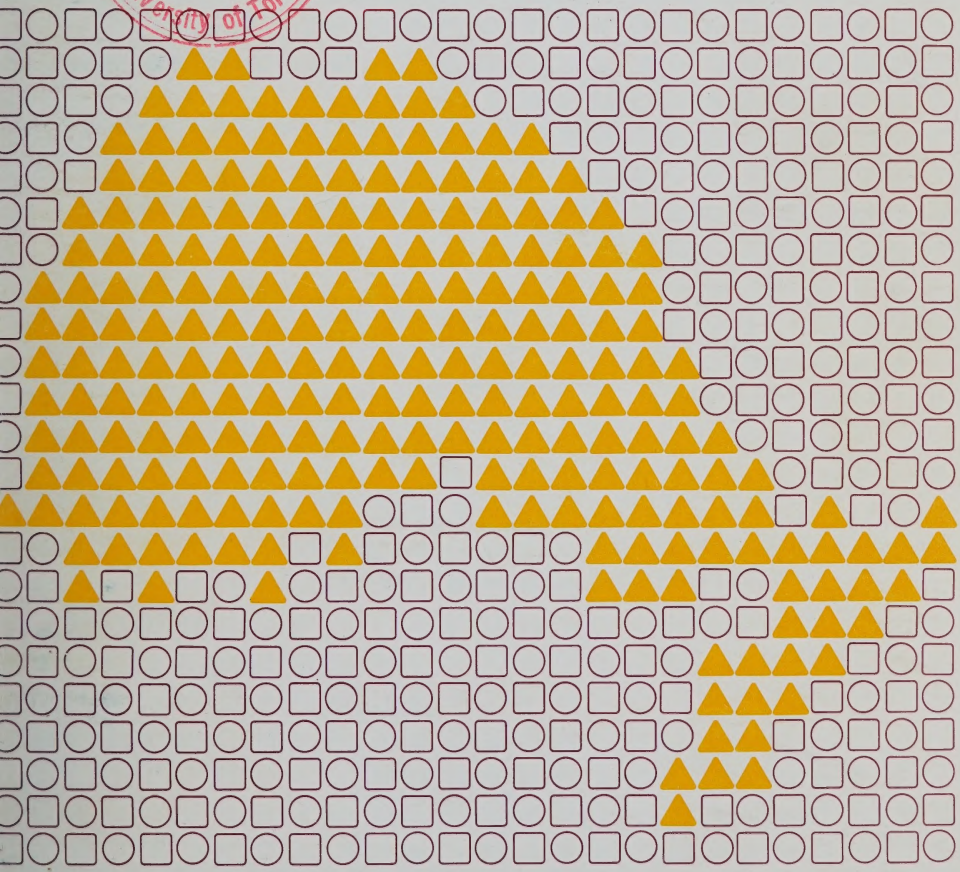
Volume 11, Number 2, Spring 1990

Labour Perspective on Science and Public Policy

New Approaches to Worker Compensation

Review of Cobalt-Related Lung Disease in Ontario

Occ.Hygiene Instruments: Calibration Principles, Process and Pitfalls



Editorial Board

Editor
Dr. Mark Nazar
Members
Dr. David K. Leong
Dr. Gary M. Liss
Dr. Peter L. Pelmear
Mr. Gyan S. Rajhans
Dr. J. Roos
Miss Catherine Wilbraham

Editorial Notes

While every effort is made by the publishers and editorial board to see that no inaccurate or misleading opinion or statement appears in the Journal, they wish to make it clear that the views expressed are those of the writers and do not necessarily reflect official opinion or policy. Accordingly, the publishers and the editorial board, and their respective employees, officers and agents, accept no liability whatsoever for the consequences of any such inaccurate or misleading opinion or statement. Permission to reprint any material herein, with credit to the Ontario Ministry of Labour, may be obtained upon written application to the editor.

Contents

Gary Cwitco — Labour Perspective on Science and Public Policy *40*

W.M. Maehle, M.D.
J.O. Roos, M.D., FRCP(C) — Review of Cobalt-Related Lung Disease in Ontario *53*

Elizabeth Kaegi, M.B.Ch.B., M.Sc. — New Approaches to Worker Compensation *60*

Ugis I. Bickis, B.Sc.(Hons.), M.Eng. — Occ. Hygiene Instruments: Calibration Principles, Process and Pitfalls *71*

Book Review *86*

Recent Publications Available from the Government Book Store *88*

News and Notes *89*

Coming Events *90*

Additional copies of this publication may be obtained from the Ontario Government Book Store, 880 Bay Street, Toronto, Ontario M7A 1N8. Price $3.00 Cheques or money orders should be made payable to the Treasurer of Ontario.

Occupational Health in Ontario

Volume 11, Number 2, Spring 1990

Notice to Contributors

Before beginning work on a manuscript, the author should read the editorial notices carefully and prepare the typescript in accordance with the instructions given. A further check of the material should be made before it is submitted, as corrections are very expensive after the article has been set in type.

The *manuscript* should be typed double spaced with three centimetre margins on each side of the page. Two copies are required for submission to the editor, and the author should keep a copy. The manuscript should contain the following components, each to begin on a new page in this sequence: title page; summary (up to 150 words); text; acknowledgements; references; tables (each table, complete with title and footnotes, on a separate page); legends for illustration. All manuscripts will be subject to referee's approval.

Illustrations should be clearly marked on the back to show number, orientation and author's name. Photographs should be good quality, unmounted glossy prints. Original art work of line drawings and graphs should be supplied. Lettering should be large enough to allow reduction. Authors should note that typewritten lettering is unacceptable, and transfer lettering should be applied.

References in the text should be numbered consecutively in arabic numerals. All references cited should be listed in the order in which they appeared, according to the reference citation recommendations issued by the Medical Section of the Library Association.

Examples

1. Cook R, Townsend JC, Ott MG, Silverstein LG. Mortality experience of employees exposed to 2,3,7,8-TCDD. J Occup Med 1980; 22:530-2.
2. Murphy S. Pesticides. In: Doull J, Klaassen CD, Amdur MO, eds. Casarett and Doull's Toxicology. 2nd ed. New York: Macmillan, 1980: 357-408.
3. U.S. Department of Health, Education and Welfare. Smoking and Health. A report of the U.S. Surgeon General, 1979.

Two copies of both the manuscript and illustrations should be sent to:
The Editor,
Occupational Health in Ontario,
Health and Safety Support Services Branch,
Ministry of Labour,
400 University Ave.,
Toronto, Ontario
M7A 1T7.

Gary Cwitco

Labour Perspective on Science and Public Policy*

Summary

This article explores the interface between science and public policy and the process of rendering decisions in the area of compensating injured workers. Possible limitations of the process and of the participants are discussed using an example of a recent decision on compensation.

Key Words: science, public policy, decision making, workers' compensation

Gary Cwitco,
National Representative,
Communication Workers of Canada,
25 Cecil Street,
Toronto, Ontario
M5T 1N1

While I speak to you today as a representative of Labour, the opinions I express are really my own. To the best of my knowledge the issue of science and its role in the development and conduct of public policy has never been addressed formally by my own organization, the Communications and Electrical Workers of Canada, or by the central labour bodies with which we are affiliated.

That is not to say that we have not considered this question, but we have yet to develop formal policies on it. As we in the Labour movement continue to consider the issues, my views and those of my colleagues are open to change. At this point I probably have more questions than I have answers about the role of science in public policy.

I hope that my comments, questions and concerns will, at the very least, provoke further discussion, both in the scientific community regarding its role in public policy and amongst policy makers regarding their use of science.

When I reflect on these issues I become angry at the treatment of workers by scientists and policy makers. I also reflect in anger about the different standards of proof used by scientists for employers in their use of chemicals and for workers who attempt to protect themselves.

I will try to identify some of the issues that arise for us in the use of science in public policy by describing an ongoing case in which I am involved. The case is a policy matter under the Workers' Compensation Board and its attendant bureaucracy — the question of compensation for women who worked at the Toronto CGE Lamp Plant who developed cancer. From this example I will draw some inferences and pose some questions that need to be answered.

Before outlining the particulars of this situation, I want to make clear a number of premises upon which most of my comments will be based. The first is that

*First presented as a speech to the Science and Public Policy Conference hosted by the Ministry of Labour, November 9, 1989.

decisions around public policy are inherently political. This requires, in societies that wish to be called democratic, that the policy decisions be made by those who can be held accountable. Further, that the process must include the full, meaningful participation of those who will be affected by the decisions.

Second, I believe that science and those who practise it are no purer or more removed from societal pressures than those in any other endeavour. Notwithstanding many claims to the contrary, science is not the impartial, unbiased pursuit of knowledge and truth. Nor are scientists and science incapable of making mistakes, incapable of bias or even of being corrupted. Science can be shaped and used conservatively by vested interests. Scientists can and do have vociferous differences of opinion on a variety of matters. These comments damn neither science nor scientists. Rather, they recognize that scientists, like the rest of us, are humans engaged in human endeavours and subject to the same human frailties.

The case I want to address is that of the CGE Lamp Plant. This issue involves a number of women who worked in the coiling department at the Dufferin Works here in Toronto who subsequently developed cancer. (Coils are the filaments in incandescent light bulbs.) As a representative of CWC I became involved in the issue when the employer closed the plant in which the situation developed and moved the operation into a plant where we represent the workers.

Nine years ago, union health and safety representatives brought the concerns of the women to the attention of their Joint Health and Safety Committee. After a year and a half of struggle in the joint committee and then in the legislature, the United Electrical Workers, which represented workers at the plant, was able to force the employer into funding an epidemiological study to be conducted by a McMaster University research team. The study was aimed at answering the question of whether or not these cancers were related to the workplace.*

Over the period in which the study was designed and carried out, the workplace parties, through their representatives on the joint committee and with the assistance of their professional staff, attempted to ensure that the study was as well and as impartially done as possible. All of this was discussed with the assistance of the

*CWC/UE Joint Submission to the Workers' Compensation Board on the IDSP Report on CGE Lamp Plant Cancer Study, May 15, 1989, pp. 4-5

study team. It took six months to develop a protocol acceptable to the employer, union and research team*

The employer was able to convince the WCB and the Ministry of Labour to participate in the funding of the study. To that end, the protocol, which was developed by the McMaster team in consultation with the joint committee, was also sent to, and approved by, those two organizations.†

During the next three years, the study went forward. It involved following up all men and women who had worked at the lamp plant for at least six months anytime in the period from 1960 to 1975. As the study proceeded, all study decisions were made on the basis of consensus of all three parties.‡

As the work on the study continued, it became evident that there was a statistically significant excess of cancers, consistent with a workplace causative agent.§ While two possible agents were discussed — methylene chloride and trichloroethylene — neither could be clearly identified as causative agents for the cancers because the company had not kept adequate records of exposure to and use of the substances over the time period studied.‖

When it became clear that the study would support the workers' claim that their disease was, in fact, linked to the work that they had done in the coiling department, the employer sent a draft of the study to specially hired private consultants in the United States.⁂ These consultants began to raise concerns about the study protocol — three years after the employer and its scientific advisers had agreed to it — arguing that the protocol was flawed and therefore the results could not be recognized as valid.

*Ibid. p. 5

†See the following pieces of correspondence, all of which were appended to the CWC/UE Joint Submission:

W.R. Paul to H. Shannon, January 18, 1983
J. Turk to H. Shannon, April 5, 1983
W.R. Paul to H. Shannon, April 12, 1983
B. Fisher to H. Shannon, May 3, 1983
R. Burak to H. Shannon, July 4, 1983

‡CWC/UE Joint Submission, op cit, p. 6

§H.S. Shannon et al, Cancer Morbidity in Lamp Manufacturing Workers, American Journal of Industrial Medicine, Vol. 14, 1988, pp. 281-290

‖IDSP, Report to the Workers' Compensation Board on the CGE Lamp Plant Issue, November 1988, p. 11

⁂CWC/UE Joint Submission, pp. 6-7

Not only was this action by the employer a violation of the agreement not to release the study to outsiders before it was released to the workers themselves, it was morally indefensible on other grounds.

The employer, acting on what we presume to be the advice of its own internal scientific consultants, decided that the protocol it had agreed to at the outset did not provide the answer it had hoped for, so it changed the rules. In this way, science was used not in pursuit of knowledge, but rather in pursuit of an answer favourable to management.

And in this process, at least one scientist who had reviewed and approved the protocol for the employer prior to the study changed his mind and condemned the protocol in a report to the board after the results were known.

We are reasonably confident that had the results of the McMaster study suggested the cancers were not significant and had no occupational link, and that as a result the unions had started to complain that the study was poorly designed, we would not have been taken seriously. We would have been labelled whiners and our concerns would have been dismissed.

But because the employer was able to mask its political agenda in a lab coat, it was able to create an aura of respectability and impartiality as it betrayed agreements it had made and disavowed a study it had supported and participated in.

When the study was completed, the CWC sent it to the WCB with a request that the study be referred to the Industrial Disease Standards Panel (IDSP) for review.

The IDSP conducted a study on the study — some of us think it conducted an inquisition — and concluded that there was not enough evidence to schedule the diseases and to provide automatic compensation to those who were ill or to the survivors of those who had died as a result of their cancers. The IDSP decision, and its reasoning for reaching that decision, raise all kinds of concerns for labour about the misuses of science in the making of public policy.

In these sorts of cases the IDSP is involved as a scientific arbiter on a public policy question within the context of the *Workers' Compensation Act*. The IDSP is a group dominated by scientists, which was established in 1985 with a mandate:

a) to investigate possible industrial diseases;
b) to make findings as to whether a *probable cause* exists between a disease and an industrial process, trade or occupation in Ontario;

c) to create, develop and revise criteria for the evaluation of claims respecting industrial diseases; and
d) to advise on eligibility rules regarding compensation for claims respecting industrial diseases. (Emphasis added.)*

It is important to emphasize that, to carry out its mandate, the IDSP is instructed by the Act to seek a causal link between the disease and the occupation that is defined as being one of 'probable cause'. It is also charged with the responsibility of establishing criteria for compensation.

The word 'probable' is neither strange nor commonly misunderstood in our everyday conversation. Workers understand that 'probable' does not mean 'certain'. Legislators usually understand this as well. I'm not sure about scientists. But most of the rest of us accept that the term 'probable' implies that there may still be some doubt.

Most individuals would not have any difficulty with any of the definitions found in The Random House Dictionary:

1. likely to occur or prove true;
2. having more evidence for than against, or evidence which inclines the mind to belief but leaves some room for doubt;
3. affording grounds for belief.†

The Act also provides guidance to the IDSP. In defining the term 'industrial disease', it indicates that this term includes:

i) a disease resulting from exposure to a substance relating to a particular process, a trade or occupation in an industry,
ii) a disease peculiar to, or characteristic of, a particular process, trade or occupation.‡

After examining the McMaster study and carrying out an investigation of the situation at the Dufferin St. plant, six of the nine members of the IDSP decided that they could not 'make a finding of probable connection between breast and gynaecological cancers among (coiling department) workers and their work-

*_Workers' Compensation Act_, Revised Statutes of Ontario, 1980, Chapter 539, section 86p(7)

†The Random House Dictionary of the English Language, The Unabridged Edition (Random House, New York: 1967)

‡_Workers' Compensation Act_, Ibid, section 1(1)(n)

place.'* They concluded that these cancers were not peculiar to or characteristic of the process of making coils at the Dufferin works nor were they the result of exposure to that particular process.

There were also two minority decisions in this case. One argued that there was a probable connection between the cancers and the workplace, and that the diseases should be added to Schedule 3 under the Act. In another minority decision, one of the IDSP members found evidence 'approximately balanced for and against work-relatedness.'†

Why did the majority refuse to recommend compensation for these women?

The IDSP report emphasizes two issues in its reasoning. One is the statistical significance of the results found by the McMaster team. The other is the inclusion in the McMaster study of a number of so-called 'index cases'.

While I will come to discuss their reasoning on these issues, I want to first point out that underlying their thinking is a fundamental flaw — and that is the confusion of their role as scientists with the distinct role they are being asked to play in the development of public policy.

Even if we were to ascribe to them the best motivation and the total absence of bias in the process of decision making and the formulation of public policy recommendations — which I am unable to do — they erred in demanding the rigour of scientific proof in place of the legal demand for probable cause.‡

There is also a serious question as to whether or not the members of the IDSP actually had accurate information before them with respect to the history of the development of the issue so that they wrongly identified the index cases. But those are matters that relate to the quality of the investigation and the quality of the staff support they received, and while it has implications for public policy, I will leave those comments aside for now.

What we believe they should have been doing was to separate the issue into two parts. First is the question of science. They needed to determine if 'science' could support a claim for compensation in this case.

*IDSP, op cit, p. 14

†IDSP, op cit, p. 16

‡For a detailed discussion of this issue see: Ison, Terence G., *Compensation For Industrial Disease Under The Workers' Compensation Act of Ontario*, September, 1989, Issued for Discussion by the IDSP

In saying this, however, I don't mean to imply that science is hegemonistic. Science can have a variety of valid opinions to offer on almost any question. We don't believe that there is a single, absolute or correct scientific opinion on any issue. Rather, there are usually a number of reasonable opinions that have scientific validity, albeit with different levels of confidence, and that they offer justification of different positions.

In any situation where different, valid choices exist, subjective judgements, assumptions or bias enter into the action of choosing what to believe or support. Sometimes these judgements or biases are conscious, sometimes not. The best of scientists examine their own work for such subjective judgements, assumptions or biases, and make them explicit. The rest play God.

A number of examples of this kind of scientific option are found in the IDSP's own report. The panel spends a great deal of time examining different interpretations of the statistical significance of the number of cancers found by the McMaster team. (Twelve gynaecological and breast cancers were found in the coiling department where only 6.68 were expected, compared to 19 found in other areas of the plant, where 23.05 were expected.)

That report comments on the choice of statistical test:

> It is worth noting that there is nothing sacred about the use of the five per cent significance level. One could readily employ a 10 per cent test of significance, in which case the risk of being wrong (that is, of accepting a finding as significant when it is, in fact, due to chance alone) at this level would be less than 1 in 10 (or less than 10 per cent).*

The IDSP concludes:

> Using a two-sided probability test of significance, there is a finding of excess breast cancer alone and of excess combined cancers of the breast, ovary and body of the uterus at the 10 per cent level. At the five per cent level, the excess of these combined cancers is of borderline significance.
>
> Using a one-sided probability test of significance, there is a finding of excess breast cancer alone and of excess combined cancers at the five per cent

*IDSP, op cit, p. 8

level. That is, the chances of making these findings using a one-sided test when there are, in fact, no excess cancers are less than 1 in 20.*

For most non-scientists either standard would suggest a potential workplace cause. That is, if the odds are 19 in 20 or even 9 in 10 that something other than chance alone caused the disease and the only thing the victims have in common, other than the disease itself, is the workplace, then it seems very probable that the workplace was the cause of the disease.

But this was not enough for the IDSP, despite their acknowledgement of the statistical significance of the findings. The majority of the panel questioned the inclusion in the cases of the so-called 'index cases'.

Index cases are those cases of illness that first come to light and that generate a hypothesis about causation. In occupational health studies, these cases are the first diseases connected to a particular workplace operation or chemical that have come to the attention of scientists. Some scientists have postulated that these index cases should be left out of subsequent studies.

Two issues arise around the index cases in the CGE Lamp Plant case. One is what happens to the power of the study to identify an industrial disease when the index cases are excluded. The fact is that the removal of index cases from consideration creates a conservative bias that may grossly underestimate the rate of illness, making it impossible to test the work-relatedness of any illness seen in small populations. As the IDSP itself pointed out, there is no good evidence that suggests that the presence of the index cases necessarily biases the results in a way that over-estimates disease.†

The IDSP refers to a study conducted by the National Institute of Occupational Safety and Health (NIOSH) that examined the results of 61 cancer cluster studies in which the index cases were retained in the analyses:

- in only 16 was there an excess of observed over expected cancers;
- in only eight of those was the excess statistically significant; and
- only one of those satisfied the criteria for exposure and appropriate latency period.‡

*IDSP, op cit, p. 13

†IDSP, op cit, p. 18

‡P.A. Schulte et al. Investigation of occupational cancer clusters: theory and practice. American Journal of Public Health. Vol. 77, no. 1 (Jan. 1987) pp. 52-56

> When a cluster arises through a chance deviation from the general population rate of cancer, the distribution of exposure deviations and of latent periods will also be determined by chance. A double coincidence is needed to produce a cluster which has credible exposure and latent periods. Therefore, elimination of clusters which do not satisfy exposure and latency requirements provides a second test for the cluster to pass.*

In other words, if the women who have the cancers are among those who have the greatest exposure (longest period working in the coiling department) and have an appropriate latency period between first exposure and onset of the cancer, then the 'cluster' is even less likely to be caused by chance. This is the case for the CGE workers.

On the basis of these findings, the IDSP itself concludes that the chances of a 'cluster' passing all of these tests (as the Lamp Plant study does) from chance alone are 1.6 per cent or only 1 in 62.†

Given, once again, that the IDSP was supposed to rule on the basis of probable cause, these findings would seem to negate any concerns raised by the IDSP members about the appropriateness of index cases being left in the study.

This, of course, leaves aside the fact that we firmly believe that the IDSP incorrectly identified the index cases here. The original cases came to light in early 1980 when five women in the coiling department brought their health problems to the attention of the union health and safety representative. Of these women, only one had breast cancer. If these cases are removed as 'index cases', then the numbers of cancers found by the McMaster study are still statistically significant.

After the early complaints were made, the plant doctor promised to investigate the situation and report to the joint health and safety committee. His initial verbal report was that there was no problem. However, a promised written report was delayed for almost a year and a half. In the meantime, the union insisted that a proper epidemiological study be conducted. While the plant doctor did finally report in September 1982 and documented eight cases of breast and gynaecological cancer in the coiling department (the McMaster study found 12 cases of these cancers), his report was not the

*IDSP, op cit, p. 18

†IDSP, op cit, p. 18

initial indicator of a problem, and was most definitely not what generated the request for a full-fledged study. And this report was clearly not satisfactory to either of the workplace parties or they never would have gone ahead with a lengthy study by the McMaster team.

Nevertheless, the IDSP has characterized the cases identified by the plant doctor's report as 'index cases' and has cast doubt on the significance of the McMaster study by so doing.

From the workers' perspective there are at least two competing yet scientifically valid analyses of some of the key issues in this case — differing levels of significance and the question of removing or retaining the index cases.

How does a policy maker choose between equally valid scientific positions? It is clear that a choice must be made and that the making of that choice can in no way be termed scientific. It is, rather, political.

That brings us to what we believe is the second part of the job the IDSP has been asked to do — to determine how the scientific evidence and the scientific options that the evidence presents fit into the policy framework that has been established in law.

To carry out this task, the IDSP needed to ask itself the following question:

> *Is there evidence that inclines the mind to believe that there was exposure to a substance in the process or that the process itself used in the coiling department was likely (not certainly) the cause of the cancer found in women workers in that department?*

The IDSP considered evidence that strongly suggests a link between the diseases and the workplace. They also considered the possibility that the diseases were only a chance 'cluster'. Which argument is stronger?

The IDSP points to the lack of evidence on the specific agent or agents that may have caused the cancers. Evidence *was* presented to the IDSP showing that methylene chloride, trichloroethylene and thorium oxide — all potential carcinogens — were used in the coiling department at times. (The information reported by the IDSP that thorium oxide was used in the plant 'but that its handling in loose form was confined to another area of the plant', turned out to be incorrect.* Workers

*Report by D.A. Marsden, Consultant, Environmental Radioactivity, Ontario Ministry of Labour, December 6, 1982 showed levels of 4500 pCi/gm of Th-232 in dust samples taken in the CWD.

in the coiling department *were* exposed to thorium oxide.) However, the company claims to have few records with respect to amounts used, the years in which they were used, and exposures suffered by the workers. This raises another important question for policymakers:

> *Who has the obligation in this kind of policy process to obtain and present evidence? Must the workers provide the scientific evidence necessary to overcome any doubts scientists may have about the work-relatedness of their illnesses? If so, what are the implications of that position for public policy?*

Another issue of concern to us is the following:

> *If scientific information is absent (as a result of a failure on the part of employers to keep or produce records, or for any other reason), is the policy maker obliged to act as if the information is available or is it simply excluded from the decision-making equation?*

If the absence of scientific information cannot be used to negate available scientific information, then, in this case, it would appear that the statistically significant link between disease and work would be stronger evidence than the possibility that, for example, any of the so-called confounding variables relating to these cancers (and breast cancer specifically), about which there is no information with respect to this case, were responsible. Again, the policy issue here is to determine a probable cause.

Scientists claim that they can only offer opinions based on what they know, yet, in this case, it appears that what they know is less important than what might be.

But back to the main point, the panel would then have to review the competing scientific analyses in the context of that policy mandate — to find probable cause — and come to a conclusion. Had they followed that procedure, I am confident that the panel would have been forced to reach a different conclusion. That is what the law demands of them.

However, in this context we believe the law is poorly drafted in that it gives the responsibility to make recommendations and decisions with respect to public policy to the wrong people. The scientists should not be those who control the development of public policy; they are poorly equipped to fill that role. Their role should be

limited to answering specific technical questions that the policy makers consider important.

That is not to say that scientists have any less right than anyone else to become involved in the policy-making process, but they must meet the same criteria of accountability as anyone else in the system.

There is also an important additional concern that science, because of its conservative nature, fails to challenge conventional wisdom and move forward from established, but inadequate or incorrect, patterns of thinking. And even when the established paradigm is, in fact, challenged, scientists are slow to admit that what they had believed to be true is, in fact, wrong. That was true in the time of Galileo and it is true today.

A classical example of this (not directly related to the case I have described) is the reliance on and defence of time-weighted-averages as a mechanism for controlling exposure of workers to toxic substances. The reality is that TWAs have virtually no scientific validity. They may be economically acceptable, they may be practically easy to measure or enforce or there may be any other number of reasons why particular interests prefer this type of standard, but there simply isn't a body of literature that creates any sense that workers who have had their exposures to substances regulated on that basis have, in any way, been protected from harm.*

In Ontario a joint committee made up of employers and trade union representatives has reached a consensus that the standard eight-hour or 40-hour TWAs have not been scientifically validated. Yet we continue to use them. We continue to expect workers who have their exposures to toxic substances regulated by these TWAs to believe that science and the policy makers who have accepted TWAs as regulations are really serious about protecting their health.

How can anyone justify the differences in the demanded level of scientific proof that is required of workers when they try to get compensation for diseases they allege come from the workplace (like the women at the lamp plant) and the virtual absence of such parallel demands on manufacturers, employers and governments when they and their agents determine that substance A or B can be safely used over a 40-hour period. . . . and so on. The answer is that there is no justification.

*On the contrary. More than 15 studies have been conducted on the issue of whether or not the TWA actually provides protection against the negative consequences of acute-acting substances. Not surprisingly, the overwhelming conclusion is that they do not.

Science and public policy are interwoven in the areas of health and safety and compensation. They should continue to be related, but we believe that there must be more thought given to the relationship and more clearly defined parameters for the extent to which science is misused to create policies of preference.

Thank you.

Acknowledgement

I wish to thank Jennifer Penney for her invaluable assistance in editing this presentation for publication.

Résumé

Cet article analyse les relations existant entre la science et la politique gouvernementale et les mécanismes permettant de prononcer une décision d'indemnisation des personnes victimes d'accidents du travail. Les éventuelles limites de la procédure et des participants sont abordés et illustrés par une récente décision d'indemnisation.

W.M. Maehle, M.D.
J.O. Roos, M.D., FRCP(C)

Review of Cobalt-Related Lung Disease in Ontario

Summary

Eleven subjects with clinically diagnosed hard metal disease associated with past tungsten carbide-cobalt dust inhalation had predominantly small irregular opacities on chest X-rays and a variety of functional abnormalities. In a survey of 643 workers exposed to hard-metal dust, six persons showed both small inspirations on chest X-rays and a spirometric pattern consistent with a restrictive ventilatory defect. The findings suggested the need for further investigations for possible hypersensitivity pneumonitis or developing pulmonary fibrosis (hard metal disease) in this group.

Key Words: cobalt, hard metal disease, tungsten carbide, pulmonary fibrosis, hypersensitivity pneumonitis, alveolitis

W.M. Maehle, M.D.,
J.O. Roos, M.D., FRCP(C),
Medical Service Chest Clinic,
Health and Safety Support Services Branch,
Ontario Ministry of Labour,
880 Bay Street,
Toronto, Ontario
M7A 2C7

Cobalt is a metal produced as a by-product of silver and gold mining. It is used for binding other metals utilized in manufacturing hard metal. The latter is used to produce power saw tips, drill bits and parts of jet engines, among other things.

Cobalt salts are also used as colouring agents for glass and ceramic glazes. The industrial applications of cobalt-containing products are many, and with their manufacture come certain hazards first described in 1940 by Jobs and Ballhausen.[1]

The original hard metal disease (HMD) consisted of irreversible interstitial fibrosis. Subsequently, two other clinical syndromes were identified, namely, airways obstruction[2] and a form of interstitial pneumonitis or alveolitis,[3] which may disappear or get better upon cessation of exposure or which may progress to irreversible pulmonary parenchymal fibrosis.

The potential reversibility lends relevance to surveillance programs since they could be used to alter the outcome of cobalt-related lung diseases.

The Ontario Ministry of Labour and the Workers' Compensation Board (WCB) of Ontario co-operate in monitoring workers at risk of developing chronic occupational lung disorders, including HMD. The Chest Clinic at the Health and Safety Support Services Branch of the Ministry of Labour operates a system of mobile and stationary surveillance units and the WCB refers claimants for the pneumoconioses to the Occupational Chest Disease Review Committee (OCDRC), a group of eight physicians and a consultant pathologist, who are asked to determine whether an occupational lung disease is present and, if so, what the medical impairment rating would be.

This paper describes findings in workers who submitted claims to the WCB following cobalt dust exposure. It also presents some results from an ongoing review of MOL surveillance data on cobalt dust-exposed workers.

The OCDRC recommended acceptance of the diagnosis of HMD and estimated an impairment rating on the first claim for cobalt-related disease in 1971. Subsequently, eight more cases have been diagnosed.

A case of sub-acute alveolitis thought to be due to inhalation of cobalt dust was recognized in 1985, and the WCB has, independently, also accepted one case of occupational asthma that may be related to cobalt exposure. A total of 11 claimants have been examined by the Occupational Chest Disease Review Committee.

The first exposure of any of the hard metal disease claimants took place in 1940 and the latest first exposure was in the late 1970s, the remainder being evenly spread between these years.

Although the HMD claimants ranged in age from 47 to 62 at the time of their first examination by the OCDRC, the cases of alveolitis and asthma presented about the age of 30.

The time between first symptoms, which were often difficult to demarcate exactly, and the allowance of the claim ranged from six months to twelve years, with a median of four years.

In most instances, impairment allowance was awarded on the first examination. The current impairment ratings ranged from 20 to 100 per cent, with three claimants receiving 100 per cent ratings, three receiving 30 per cent, four receiving 20 per cent, and one receiving no impairment rating.

The ages at death of three of the subjects were 76, 62 and 59 years. Two died of myocardial infarction and one of respiratory failure. All had marked signs of hard metal disease.

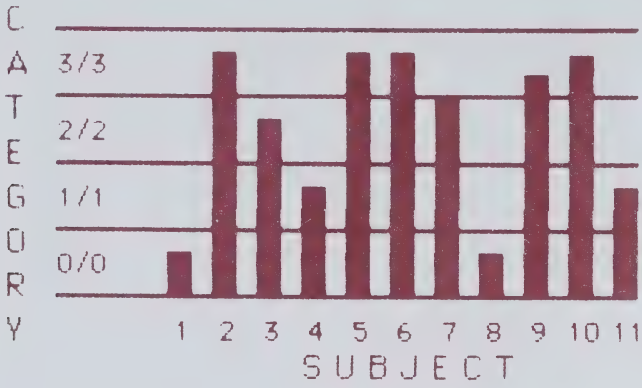
The symptoms and clinical findings included breathlessness in 10 of the 11 persons seen at the OCDRC. Eight claimants complained of some degree of cough, five of these had cough productive of sputum, and three others had no cough.

Radiologically, the X-rays were characterized by the finding of small irregular opacities. The profusion categories ranged from 3/3 to 1/1 on the ILO 1980[4] classification scale with the exceptions of the worker with asthma and the non-compensated worker, who were categorized as 0/0 (Figure 1). The primary shape/size categories described by various readers of the chest X-rays were 's' or 't' with one 'r' rating. The secondary small opacities were either 't's' or 'u's' in most instances.

The person with alveolitis had an otherwise normal chest X-ray, but showed a persistent loss of total lung capacity, both radiographically and physiologically.

Lung function tests were done at rest and on exercise. The forced vital capacity (FVC) measurements in most claimants were below the predicted mean for the age,

Figure 1 **Profusion of Small Opacities**



size and sex, and in four of the 11 claimants fell below the 95th percentile of reference values. There was no consistent change in FVC from the first to the last examination in those claimants on whom both measurements were available. Changes that were noted were small. The total lung capacity (TLC) was more variable at the start, and follow-up measurements of this procedure showed increase in most of the few patients who had double measurements.

The FEV_1/FVC ratio decreased in five of seven claimants on whom repeat measurements were available.

The change in single breath diffusing capacity of the lung (DLCO) from first to last examination showed slight drops in three claimants and, in two, showed slight increases.

An open lung biopsy was done on three claimants and transbronchial biopsies on three, one claimant having both procedures. The overall experience of the OCDRC has been that transbronchial lung biopsies did not contribute usefully towards establishing a diagnosis of widespread parenchymal interstitial fibrosis since peribronchial fibrosis is quite commonly diagnosed in persons who have no significant parenchymal involvement. X-ray microanalysis for metals was done in two cases. Cobalt, tungsten or nickel particles were not found. There was some difficulty in determining what weight to give to this finding since disappearance of cobalt has been noted in the literature even in cobalt-exposed workers. In some of the latter, however, other

metallic particles were found, and such were not found in the group under review. The OCDRC has diagnosed claims as HMD despite the lack of evidence of metal particles in the lung parenchyma.

Alveolitis Survey

The one claimant who was aged 28 when first diagnosed as having probable cobalt dust-induced alveolitis had been followed over five previous routine examinations with X-rays and forced expired spirometry and was, on each occasion, found to be normal. Subsequently, shortness of breath and cough developed and on re-examination he was found to have persistently reduced lung capacity, both radiologically and physiologically. This led to a review of the Ministry of Labour's available films and spirometric results on the cobalt dust-involved work force in Ontario.

Two groups of workers were compared: Cobalt workers from 13 companies and open-pit quarry workers from 54 companies. Quarry workers had previously been noted to be relatively free of pneumoconiosis and were selected for this reason. The study group of cobalt workers numbered 643 and the control group of quarry workers 2,423. Counting previously done serial studies on these individuals, 1,520 X-rays of cobalt workers and 2,305 films of quarry workers were read using the ILO 1980 protocol. Similarly, a total of 1,528 spirometric tests had been done on the cobalt workers and 4,389 on the quarry workers.

Per capita, both cobalt and quarry workers were similar in their smoking histories, with about one-half of the work force being current smokers and the remainder being evenly split between ex-smokers and never-smokers. There were only a very few pipe, cigar or occasional smokers.

All films on cobalt-exposed workers were re-read by two readers using the ILO 1980 Code, who were asked to comment on X-ray quality. The film quality categories on all quarry workers were taken from films that had not been re-read. The quality ratings were similar in each group.

It is not known whether this represents bias due to a special focus of interest in the cobalt workers or whether, in fact, the X-ray quality was slightly worse in the cobalt group.

Since one of the presenting findings in the index case with alveolitis was decreased total lung capacity, a specific search was made among the cobalt workers for incomplete inspiration. In comparison to the quarry

workers, the cobalt group had a larger number of films showing incomplete inspirations, defined for this study as a right hemidiaphragm at a level higher than the fifth anterior interspace. The total number of incomplete inspirations among the cobalt workers was 30 and among the quarry workers, 13. These represent 0.02 and 0.01 per cent for the respective groups of X-rays read. The difference could represent bias induced by a particular focus of interest in the cobalt-exposed workers. The primary and secondary small opacities found in the cobalt group showed a sharp peak in the number of cases of 's' small, irregular opacities and a small peak for 'q's'. No peaks existed for the quarry workers (Figure 2). However, it was also found that a similarly high peak for the cobalt workers occurred in the 0/1 category, which represents a difficult area of discrimination and which could be explained by suboptimal X-ray technique or by bias due to focus of interest.

There was no difference per capita in the findings of normal, obstructive or non-obstructive spirometric patterns between the cobalt and quarry groups (Figure 3).

Figure 2

Primary Small Opacities: Cobalt Workers vs. Quarry Workers (absolute numbers)

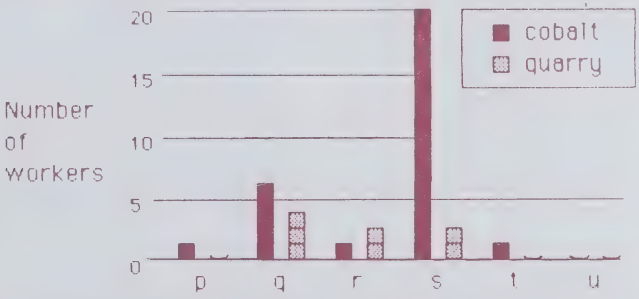


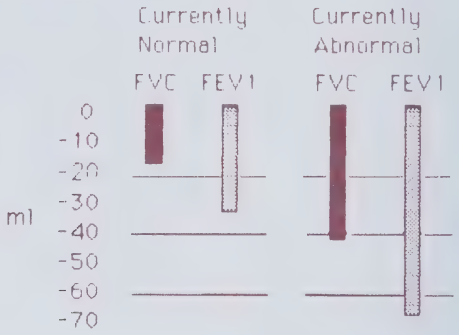
Figure 3

Spirometric Patterns: Findings per 1000 Workers in Cobalt or Quarry Dust Exposure

The average annual decrement in FVC/FEV_1 in the cobalt workers was a normally predicted 19 ml per year in FVC and 34 ml per year in FEV1 in those workers who were normal at the last examination. Those who were abnormal at the last examination had greater annual fall: 47 ml FVC and 64 ml FEV_1 (Figure 4).

Figure 4

Average Annual Decrement in FVC and FEV_1 in Cobalt Workers



Sufficient spirometric information was available to do an evaluation of progression of FVC or current FEV_1/FVC ratio on 22 workers who had poor inspiration on chest X-rays. In 16 individuals no demonstration could be made of a consistent restrictive progression of simultaneous worsening of inspiration together with a worsening FVC or an abnormally high FEV_1/FVC ratio. It was believed that those workers were unlikely to have a restrictive ventilatory defect due to developing alveolitis or HMD. However, in six cobalt workers such a pattern could not be ruled out without additional investigations.

Review

As seen in our population:

1. Hard metal disease has a wide range of severity.
2. It may be severe, but once established may not be strongly progressive.
3. Symptoms are not always a good early sign of cobalt lung-related disease.
4. There may be a reversible initial phase. If this is true, it should be used to advantage through improved surveillance methods.

5. Early suggestions from an ongoing review of current hard metal workers indicate that fine irregular opacities on the chest X-ray and incomplete inspiration may be more common among cobalt than quarry workers, but this lead may be in error for several reasons and must be checked carefully.

6. Six cobalt workers out of 643 (0.01 per cent) showed a clinically significant drop in FVC together with a finding of 'poor inspiration' on the chest X-ray. These workers need additional follow-up.

Résumé

Les radiographies du thorax subies par onze sujets atteints de fibrose pulmonaire interstitielle diffuse par métaux durs associée à l'inhalation de poussière de carbure de tungstène et de cobalt ont révélé la présence de petites opacités irrégulières ainsi qu'un certain nombre d'anomalies fonctionnelles. Lors d'une étude réalisée auprès de 643 travailleurs exposés à des poussières de métaux durs, six personnes ont révélé de légères inspirations au cours des radiographies et une image spirométrique montrant la présence régulière de troubles ventilatoires restrictifs. Ces résultats démontrent la nécessité de réaliser une enquête plus approfondie dans le but de déceler, au sein du groupe, d'éventuels cas de pneumopathie par hypersensibilité ou de fibroses pulmonaires naissantes (fibrose pulmonaire interstitielle diffuse par métaux durs).

References

[1] Jobs H, Ballhausen C. Powder metallurgy as a source of dust from the medical and technical standpoint. Vertrauensartz u. Krankenkasse 1940; 8: 142,

[2] Sjogren I, Hillerdal G, Andersson A, Zetterstrom O. Hard metal lung disease: The importance of cobalt in coolants. Thorax 1980; 35: 653,

[3] Coates EO Jr., Sawyer HJ, Rebuck JW et al. Hypersensitivity bronchitis in tungsten carbide workers. Chest 1973; 64: 390,

[4] International Labour Office, Geneva: Occupational Safety and Health Series 22 (Rev. 80). Guidelines for the use of ILO international classification of radiographs of pneumonoconioses. Revised edition 1980. ILO Publications. CH-1211 Geneva 22, Switzerland.

Elizabeth Kaegi M.B.Ch.B., M.Sc.

New Approaches to Worker Compensation

Summary

New initiatives with respect to worker injury and rehabilitation are discussed with specific reference to community clinics, regional evaluation centres and the impact of a medical rehabilitation institute. Various aspects of the rehabilitation of injured workers are discussed, and plans for the near future are presented.

Keywords: workers' compensation, rehabilitation, return-to-work

Elizabeth Kaegi, M.B.Ch.B., M.Sc.,
Vice-President,
Policy and Specialized Services,
Workers' Compensation Board,
20th Floor,
2 Bloor Street East,
Toronto, Ontario
M4W 3C3

Introduction

The Ontario Workers' Compensation Board deals with about half a million claims annually from injured workers. Half of those claims involve health care services only, but the other 250,000 workers lose some time from work because of the nature of their injury. The vast majority return to their pre-injury work, but there is a significant number of workers who encounter substantial rehabilitation problems. To meet the needs of these workers better, the Ontario Workers' Compensation Board has recently developed new approaches to both medical and vocational rehabilitation. These new initiatives hold the promise of more complete and more timely recovery from workplace injuries with all the advantages that that implies.

Medical Rehabilitation

With respect to medical rehabilitation, the strategy developed in 1988 addresses a number of significant deficiencies in the pattern of health care for injured workers. The major focus of this strategy is on soft-tissue injuries. These apparently minor injuries — sprains and strains — account for 140,000 lost-time claims each year. Too often, workers who have suffered what seem to be relatively minor injuries are disabled for months and months, and a significant number of these workers never recover sufficiently to return to their former level of activity, either in their personal lives or at work. Effective treatment programs for these patients are often difficult to identify, particularly in small centres. Furthermore, services that do exist can frequently not be made available in a timely manner, and lengthy waiting lists are common.

In late 1986 and through 1987 the WCB established a number of pilot projects in 12 locations across Ontario to study alternative approaches to the medical rehabilitation of individuals with soft-tissue injuries. The board's senior medical consultant, Dr. Robert Mitchell, designed the pilots to test and refine a treatment model developed by Dr. Alf Nachemson in Sweden,

Dr. Tom Mayer in the U.S., sports medicine clinicians and others. They have demonstrated that patients who have suffered back strain are likely to suffer several more bouts of back trouble, whether they return to full activity or not and that the best treatment program is one that returns these patients to their regular activities as soon as possible after their injuries. By adding an educational program to help the patient deal with subsequent bouts, individuals are placed in a better position to capitalize on their abilities and live fuller, more productive lives. From May 1987 through May 1988 the pilot clinics offered treatment based on these new concepts. The results of the pilots were clear. Patients who were treated in this model recovered faster and more completely than patients in a matched control group. Furthermore, the incidence and severity of recurrences and the degree of permanent clinical impairment seemed to be at a lower level than in the control group. In addition, injured workers who were treated at community clinics expressed their support and appreciation for the program in a patient satisfaction survey: 67 per cent said that their general fitness level improved as a result of the program; 79 per cent said they continued an exercise program on their own and 82 per cent indicated that they would recommend the program to other people with similar injuries.

Community Clinics

Based on these results, results that I am pleased to say have recently been accepted for publication in the international medical journal *Spine*, the board has moved to facilitate the establishment of a network of 'community clinics' providing treatment programs patterned on pilot projects as part of its new medical rehabilitation strategy. It is envisaged that there will be 50-100 of these clinics across the province after full implementation of the strategy, and we are happy to report that we expect about 50 to operate very soon. The community clinics, which are paramedical in orientation, will accept patients referred to them by treating physicians as early as five days after a soft-tissue injury. This early quick referral into a treatment program will help the patient maintain a pattern of leaving home every day for work — this time, though, for work at rehabilitation.

Patients referred for treatment at a community clinic attend the clinic for one hour per day in the first week and two hours per day in the second week. Treatment consists of intensive, individualized physiotherapy, in-

cluding physical modalities to relieve pain, combined with gentle, active exercises increasing each day as the patient improves and the injured part regains mobility and strength. By the end of two weeks of treatment, the majority of patients will have recovered to the point of full activity — without substantial loss of general fitness.

For patients who have not recovered, a half-day program five days per week for a maximum of four weeks is available. The half-day is filled with individual physiotherapy, group exercise to maintain general fitness, educational sessions covering the mechanics of injury, and injury prevention and care. The program becomes progressively more active over the four weeks and is quite physically demanding.

One of the chief features of the new program is the active involvement of the patient in the rehabilitation process. The tendency in the past has been to let patients be the passive subjects of rehabilitation efforts, but with the new approach, patients participate very actively in the process of getting well, setting their own goals and planning their programs.

There is no doubt that this is an expensive program. When fully established, it is projected that the community clinic system will serve about 100,000 workers each year and that it will cost the board between $40 and $50 million dollars annually in health care costs. But, as indicated, patients in these programs have been shown to recover faster and more completely. The results of the pilot projects allow the board to project a shorter period of disability, and, consequently, a shorter duration of income support will offset the increased health care costs associated with providing the more intensive programs and expensive health care described above.

Some community clinics have already started operating, and we expect that more than 50 will be operating in the very near future. The clinics will all be independent of the WCB, and the board will purchase services from them on a fee-for-service basis. The board's goal is to encourage the establishment of enough clinics that all injured workers will have access to the programs within a reasonable commuting distance from their homes. Recognizing the services that chiropractors already provide to injured workers, the board is working with the Ontario Chiropractic Association to facilitate the development of three chiropractic community clinics, set up on a similar basis to the paramedical clinics, to provide a daily, active, intensive program of treatment, exercise and education.

Regional Evaluation Centres

The new community clinic system constitutes, however, only the first tier of new services under the board's medical rehabilitation strategy. The second tier was designed to deal with a smaller, but still substantial, number of workers — about eight to ten thousand per year — whose recovery from an injury is prolonged. These patients may have entered a community clinic program and, for some reason, are not responding to treatment or they may have been receiving care outside the clinic stream.

A second tier of services consisting of approximately 12 regional evaluation centres has been established to aid treating physicians in sorting out the complexities of these cases and also to assist the board in discharging its responsibility to provide for the necessary rehabilitation of injured workers. At least 10 of these regional evaluation centres will be in operation shortly.

The centres will see patients referred to them by their treating physicians or by the board. They will provide comprehensive medical or health care assessments of the patient to confirm the diagnosis, to review the treatment to date, to establish the prognosis and to outline recommendations for future treatment. The assessments will be multidisciplinary and will include physiotherapy, occupational therapy and, when necessary, social work or psychological assessments in addition to the medical and/or surgical consultations required.

Those individuals whose conditions have stabilized medically but who are nonetheless left with significant functional restrictions may also require a 'functional abilities evaluation' to identify their abilities and any limitations for returning to work. These assessments will be requested through the WCB, and the report of this thorough, multi-disciplinary functional assessment will form the basis for the development or refinement of a vocational rehabilitation plan for an individual.

The regional evaluation centres will also provide consultative and advisory services in their regions, and they will have a significant research and education function. Like the community clinics, they will function independently of the WCB, and the board will contract with them to provide the needed services on a fee-for-service basis. As with community clinics, the regional centres will be encouraged to provide services to clients other than injured workers.

Medical Rehabilitation Institute

The third tier of the medical rehabilitation strategy is a provincial medical rehabilitation institute to be established very shortly. The institute will be supported by an annual grant from the Workers' Compensation Board, although it will be free to seek additional funding from other sources. It will be operated as an independent organization with its own board of directors.

One of the most challenging responsibilities of the institute will be to conduct and co-ordinate research into the most successful methods to achieve the effective and efficient medical rehabilitation of injured workers. The institute will also be involved in monitoring the quality of the care delivered in the community clinics and the regional evaluation centres, both to ensure that there is consistency in care across the province and to observe and learn from regional variations in experience. If one clinic is getting particularly good results from a specific education program or exercise technique, the institute will be able to identify this and perhaps recommend that other clinics adopt the same practices.

Because it will be on the leading edge of medical rehabilitation, the institute will also work with the professional schools and associations to develop curricula for training health care professionals in the newest rehabilitation theory and techniques.

Vocational Rehabilitation

With this new multilevel program of enhanced care, it will become more and more likely that injured workers will return to their full pre-accident activities. Those who do suffer more serious and permanent injuries should experience less permanent disability. For those workers whose permanent disability prevents them from returning to their former jobs, the board developed a new approach to vocational rehabilitation in 1988.

The goal of this new vocational rehabilitation strategy is to help this special group of workers by providing them with assessment, training and specialized programs designed to lessen the impact of the injury on the worker and to assist the worker to the greatest extent possible to return to his/her former situation. From an earnings point of view we will try to help the worker re-establish his/her pre-injury earnings profile.

The earnings profile of a worker is his/her pattern of annual earnings over a working lifetime. The chart in Figure 1 gives two somewhat simplified examples, which we might review briefly. The first earnings profile represents an individual who starts off in a professional

training program. After several years of training at a low income, qualifications are gained and a new higher income level is achieved and maintained. The second earnings profile shows an individual who works progressively through an organization gaining skills and experience through on-the-job training. Regardless of when in a person's life an accident occurs, the board will aim to help the individual achieve the earnings profile that was reasonably anticipated before the injury.

Return to Work

To guide vocational rehabilitation efforts, a hierarchy of objectives was established. First, all efforts will focus on returning the worker to his or her pre-injury job. The first question board staff will ask is this: Is it possible that, with some additional medical rehabilitation, the worker could return to the pre-injury job? If the answer is no, the next question is: Are there modifications to that job that could be made that would allow a return?

The emphasis on return to the pre-injury work is intentional and well founded. If such a return is achieved, disruptions to the worker's life — and to the employer's operations — are minimized. The worker's dignity is maintained, his or her social support network

continues, and the income level is kept relatively stable. Sometimes, simple modifications to the job in terms of the nature of the tasks or their timing are all that are required. The board provides assistance, both technical and financial, in this regard.

If it appears that a return to the pre-injury job is not open to the worker, the availability of a *comparable* job with the accident-employer will be investigated. The rationale for this is that the board has found that the maintenance of the worker-employer nexus is important and increases the likelihood of a successful return to work.

If a comparable job is not available with the accident-employer, the board will proceed to investigate the availability of a comparable job with another employer. If no such job is available, the board will work with the worker to find alternative but suitable work with the accident-employer, and if that is not possible, then with another employer.

Just as important as this hierarchy of objectives is the timing and method of working through the hierarchy. The board accepts the conventional wisdom that care should be taken to ensure that an intervention is only made where vocational rehabilitation is likely to be necessary. Automatic early intervention carries with it a risk of delays and inappropriate interference in the life of a worker who does not need a service and who would have returned to his/her former work without the assistance of the board or an external party.

The Ontario board's approach is, therefore, to refer an individual for vocational rehabilitation as soon as it is apparent that the *worker is unlikely to return to his or her pre-accident job*. For severely injured individuals, this will be almost immediately following injury. Workers who remain off work for 45 days after injury will be contacted by the board at that point and every six weeks thereafter to determine specifically whether return to work is unlikely and thus whether vocational rehabilitation services are required.

In any event, all workers who have been away from work for six months need, at the very least, vocational rehabilitation assessments. If such an assessment reveals that a worker could benefit from a vocational rehabilitation program, one will be offered.

Once a vocational rehabilitation program is in place, there is a two-week contact cycle to ensure that progress is being made.

Once vocational rehabilitation service is offered to a worker, it is the *style* of that service that is one of the

strategy's most distinguishing features. The old methods of vocational rehabilitation had a counsellor provide support and guidance to a worker in order to facilitate a return to work. Under the strategy, the key board staff person is a vocational rehabilitation *caseworker* who will work *with* the injured worker and the accident-employer to develop a reasonable and workable plan for rehabilitation. The plan will be in writing and it will outline the respective responsibilities of the worker, the employer and the case worker. It contains a full list of necessary activities and a timetable for the rehabilitation program.

This notion of a clearly defined, mutually agreed and written contract is one that has been successfully used in the social work field. It structures expectations, it clarifies who must do what when, and it embodies a commitment from all the relevant players to achieve the goal of the vocational re-integration of the worker.

Once the vocational rehabilitation plan is agreed to by the worker, the employer and the caseworker, a copy is sent to the worker's treating physician to ensure that the worker's medical condition does not preclude any of the planned activities, and to keep the physician fully informed with respect to the program the individual will be pursuing.

As the plan proceeds, the board's caseworker is responsible for ensuring that the parties meet their commitments and also for procuring the necessary expert advice and services called for in the contract. These may include specialists within the board, for example: a social rehabilitation counsellor, a worksite analyst or ergonomist or a modified work program specialist. Other special programs outside the board may also be arranged — a functional abilities evaluation carried out at a regional evaluation centre, a psychological assessment of aptitude and skills, training programs, etc.

Social Rehabilitation

It is significant that the vocational rehabilitation strategy separates vocational rehabilitation from social rehabilitation. In the past, there has been some confusion about the true role of board vocational rehabilitation counsellors. Some who were particularly skilled at counselling adopted this as their prime activity, sometimes at the expense of concentration on vocational issues and with a consequent loss in the necessary momentum of the process. Others tended to focus clearly on the vocationally related activities and paid insufficient attention

to the problem of the worker's adaptation to his or her disability.

Obviously, both types of service are necessary. But the board will be very clear that when a worker's problem is predominantly vocational — that is, when his/her job requires modification, when he/she needs new skills to meet the demands of a job he/she is physically capable of, or when he/she needs assistance with modification of the workplace — the vocational rehabilitation caseworker will be there to assist.

Where, however, a worker is encountering serious social difficulties that result from the injury and that are interfering with rehabilitation, one of the board's social rehabilitation counsellors will become involved. These staff will help the worker to manage personal circumstances that are impeding rehabilitation efforts and to adjust to the permanent effects on personal circumstances resulting from the injury. Referrals to other community agencies will be facilitated as appropriate, and when the difficulties are resolved, a more concentrated and effective focus on vocational issues will once again become possible. It should be noted that both vocational and social rehabilitation services provided by the board are available not only to injured workers but also to surviving spouses.

Progress to Date

In January 1989 the board piloted the vocational rehabilitation strategy in three operating units. Though it is still too early to assess the full impact of the strategy, there are strong indications that it will be highly successful. Board caseworkers have found that the involvement of the employer and physician in formulating a vocational rehabilitation plan with the worker has resulted in a higher rate of return to work and, better, still more workers returned to their pre-injury job. The development of a formalized plan with the setting of realistic time frames and goals seems to be a very effective way to achieve a greater degree of worker self-confidence and independence, which, in turn, leads to more successful vocational rehabilitation.

Workers have expressed support for their employers' early and active participation because it means that a return to work becomes a much more realistic and achievable goal. They report that they will feel more connected to both their employer and their co-workers. The minor modifications of work procedures that are often required to accommodate a disabled worker are more likely to be made.

Employers have also been overwhelmingly supportive of this strategy. They like their new role because it helps them to maintain the employment link with valued employees and also to make a difference regarding their compensation costs. As well, physicians are very receptive to being involved in vocational rehabilitation planning, and have advised board staff that they have an increased appreciation and awareness of board operations and policies as a result.

Finally, caseworkers report a more productive and positive relationship with workers and employers. The combination of early and timely intervention, the involvement of all the important parties, including the worker's physician, the clearly stated goals and the worker's own sense of involvement, participation and control are all important factors generating this change. Early referral is occurring, with the vast majority of workers being referred by 18 weeks.

The vocational rehabilitation strategy will be fully implemented across Ontario in 1990. Full implementation will see 18,000 injured workers annually receive vocational rehabilitation help from the WCB. This compares with a pre-strategy annual caseload of about 13,000. As with the medical rehabilitation strategy, a more intensive service, started sooner and available to more people, is projected to increase the board's expenditure on vocational rehabilitation.

Conclusion

As with the medical strategy, the earlier appropriate vocational rehabilitation is made available, the earlier workers will be able to return to work. The expectation is that decreasing periods of disability will more than offset the increased costs of vocational rehabilitation services. The strategies have been developed with the primary purpose of facilitating the delivery of the best services possible to injured workers. It is gratifying that this new pattern of care also promises to be very cost effective.

The Ontario WCB's tripartite board of directors has adopted these two new initiatives with enthusiasm because they represent new hope for many workers who are unfortunate enough to suffer a workplace injury. Now, more workers will recover better and faster through improved medical rehabilitation. And for those whose injuries will prevent them from returning to their regular work, the vocational rehabilitation strategy will provide the prompt, intensive services that are needed.

The key to both strategies is, of course, co-operative

effort. Guided by these new strategies, the Ontario WCB will work harder with workers, employers and health care providers to bring about solutions to the complex problems that all workplace injuries present.

Résumé

De nouveaux projets concernant les accidents du travail et la réadaptation professionnelle sont actuellement à l'étude, notamment en ce qui concerne les cliniques communautaires, les Centres d'évaluation régionaux et l'incidence d'un institut de réadaptation fonctionnelle. Divers aspects de la réadaptation de victimes d'accidents du travail sont présentés ainsi que les projets pour l'avenir.

Ugis I. Bickis, B.Sc. (Hons.), M.Eng.

Occ. Hygiene Instruments: Calibration Principles, Process and Pitfalls*

Summary

This article reviews the principles of calibration as they apply to the determination of the airborne concentration of workplace contaminants. Various sources are cited, and original information from the author's experience is presented regarding problems arising from instrumental inaccuracy. These are discussed in relation to the significance of potential errors.

Key Words: calibration, accuracy, compliance, direct reading instruments

Ugis I. Bickis, B.Sc. (Hons.), M.Eng.,
Occupational Health Centre,
Abramsky Hall,
Queen's University,
Kingston, Ontario
K7L 3N6

The Demand for Hygiene Work

In Occupational Hygiene most jurisdictions have adopted numerical Occupational Exposure Limits (OELs), based largely on the ACGIH TLV®s. Ontario, for example, had, by 1986, prescribed limits to only 10 substances by 'designation', yet, effective December 6 of that year, some 600 additional substances† became regulated by enactment of O.Reg.654/86 (Regulation respecting Control of Exposure to Biological or Chemical Agents . . .). This regulation sets limits that are referenced as TWAEVs, STEVs and CEVs. However, there is some ambiguity associated with the use of these terms since in part 2A of the regulation they are used to denote the level of actual exposure rather than the limit to exposure.

The earlier designated substance regulations (DSRs) had included Codes of Practice with regards to air sampling; requirements with respect to the calibration of personal sampling pumps, analytical instrumentation, etc., had been specified. The newer regulation has placed the onus upon employers to maintain worker exposures within the prescribed limits. By inference, the employer must be able to demonstrate that worker exposures are compliant. However, instead of detailed 'cookbook type' instructions on how to do this, there is a requirement that this be done 'in accordance with recognized industrial hygiene practice.' The Joint Steering Committee on Hazardous Substances in the Workplace will be making recommendations to the Ontario Ministry of Labour regarding future air sampling requirements.

In federal jurisdictions, under the regulations under the amended part IV of the Canada Labour Code:

(2) Where there is a likelihood that the concentration

*This article was originally written at the request of the publication *Occupational Health and Safety Canada*. It was published in part as 'Calibration: A Measure of Certainty' in the May/June 1989 (Vol.5, No.3) issue. The text is presented here with the permission of OH&S Canada.

†Actually totalling 584, according to a ministry communication.[1]

of an airborne chemical agent may exceed the value referred to in subsection (1), the concentration of the chemical agent shall be sampled and tested;

a) in accordance with the standards set out by the American Conference of Governmental Industrial Hygienists in its publication entitled Manual of Analytical Methods Recommended for Sampling and Analysis of Atmospheric Contaminants, dated 1958;
b) in accordance with the standards set out by the United States National Institute for Occupational Safety and Health in the NIOSH Manual of Analytical Methods, third edition, volumes 1 and 2, dated February, 1984; or
c) by a method that uses the test procedure set out in the United States Federal Register, volume 40, number 33, dated February 18, 1975, as amended by volume 41, number 53, dated March 17, 1976.

Thus there are various trends, similar to what was mentioned at the outset:

- an increased quantitative requirement to have hygiene monitoring performed
- an increased qualitative requirement to have responsible individuals trained, certified, competent, etc.
- an increased performance requirement that the data and the manner in which it is acquired withstand the scrutiny of peers, experts and jurists, *i.e.* that there be a conformity to at least nominal standards of professionalism.

In certain respects, phenomenal progress has been made in just a few years. Take confined-space entry as an example. Even as recently as five years ago, we came across the 'flaming rag technique' as a means to verify the presence of sufficient oxygen to sustain worker respiration in a pit that had previously been 'inerted'. This particular plant has now conformed to an instrumental approach for further confined-space entry procedure. A Toronto Star article reported that a Derbyshire coal mine was about to switch from live canaries to electronic meters. This was in December, 1986![2]

Why Calibrate?

Hygiene equipment is becoming steadily more and more 'sophisticated' in terms of sensor capabilities, displays, data logging and computer interfacing, etc. At the

same time, the installation of an increasing number of microprocessor-based controls and user-'prompts' (friendly or otherwise) makes them apparently simpler to operate. The earlier mentioned increased demand for data collection, together with the limited number of professional occupational hygienists or trained/experienced generalists available, is ironically causing an increased amount of testing to be done by inadequately prepared personnel. This is potentially dangerous.

One might get the impression (say, from commercial literature) that a given 'black box' can be used

- directly on the shop floor
- by untrained personnel
- immediately after being unpacked
- to digitally indicate concentration.

It may in fact 'work' this way, at least initially. However, we very recently received a 'demo' instrument (from a supplier) that had a factory calibration out by 50 per cent. Generally, it is important that the individual using an instrument have some understanding of its operating principles and limitations. Clearly, instrument calibration is crucial, as it may truly be a life-and-death matter.

The fundamental operating principle of all monitoring equipment involves an interaction of the airborne compound of interest (let's call it the 'contaminant') with a 'detector'. This produces some signal that is proportional either to the concentration or to the mass of the contaminant. One would hope that the signal from the detector is 'accurate', i.e. gives a true reading of the concentration of the contaminant.

However, it is the professional, legal and/or moral obligation of anyone responsible for conducting hygiene measurements to verify this empirically, i.e. by actually calibrating the instrument (or other equipment used). Calibration of a direct-reading (D/R) instrument typically involves setting two points on the device's response 'curve'. These response (or calibration) 'curves' are, ideally, straight lines, at least through the concentration range of interest. (However, at times, true 'curves' do have to be used). If we 'fix' two points on this line with gases of known concentration (our 'standards'), then the rest of the line (if it is, in fact, straight) is *defined*, for the region between the two points. Normally, we will use a 'zero gas' ('negative control', containing no detectable amounts of the contaminant of interest) to set the instrument zero, and a 'span' gas (containing a specified concentration of the contami-

nant) to set the response at the upper end of the range of interest.

One form of 'comparative' or 'relative' calibration may simply involve the simultaneous operation of several devices in workplace air. Certainly, one application of calibration may be not only to test for accuracy as might be determined in the manufacturer's lab, but, more relevantly, under the conditions that exist in the specific workplace of interest. Table 1 shows a trivial determination of 'calibration factors' for a light-scattering aerosol monitor, the GCA (now MIE) miniRAM.[3]

Table 1 **Trivial Comparison Miniram and Gravimetric**

Aerosol	miniRAM mg/m³	gravimetric mg/m³
Silica (tile manuf.)	1.1	5.7 (total) 0.5 (respirable)
buffing brass fittings	0.12	0.18
lead/dust fume (pistol-shooting)	0.23	0.31
wood dust	0.88	1.01
office dust	0.19	0.13
phenolic resin dust	5.7	5.8

To the professional occupational hygienist, calibration is a self-evident need and an almost instinctive process like the 'why', 'when', 'where', 'who', 'how many', etc. questions that are reviewed in every 'intro to hygiene' lecture. But what about the lay user of hygiene instrumentation?

- What are the reasons for calibration?
- What does calibration involve?
- How often should instruments be calibrated?

It is probably quite frustrating to read that the instrument should be calibrated 'regularly' or 'periodically'. Does this mean hourly or annually? In fact, depending on the circumstances it could mean either. This should really be a matter of professional judgement, but let's try to describe some of the factors on which calibration 'depends'.

Say you've just struck it rich in 'Vegas; you've bought a new car, and you're headed for a trip across the desert. Your fuel gauge reads 'F'. Do you have absolute faith in it? What happens if it reverts to 'E' by the

time you've crossed town? Or what if the two terminals were reversed during installation of the gauge? If it reads 'E', how many km have you got left? A fuel gauge is a very simple device, operating over one order of magnitude (say 5–50 L), with one single tangible substance (gasoline). Hygiene instruments are much more complex, sensitive, etc. Yet, a few years ago, an airplane experienced an 'emergency landing' because it ran out of gas due to miscalibration of fuel volumes! As you develop experience with your fuel gauge, you gain more confidence in the reading. Similar considerations apply to instrument calibration.

Let's first review what calibration means. To paraphrase Webster, it is 'to determine the calibre (quality)' or to 'check the graduations of a measuring instrument.' Once again, the main thing we want to achieve by calibrating the instrument is to verify and/or set (if necessary) the 'trueness' of the readings. We want to eliminate what are termed systematic errors or bias. We want to make the instrument accurate. As described earlier for D/R instruments, this typically involves setting 'zero' and 'span' adjustments. In the case of air samples collected in the workplace (say on charcoal tubes) for subsequent lab analysis, the analogous terms would be 'blank' and 'spiked' samples. Similarly, an important step in the sample collection by means of personal sampling pumps is the calibration of pump flow rate. Even the pumps used with D/R tubes (i.e. Drager, Gastec etc.) need to be calibrated.

If the calibration process is repeated, and other variables incorporated, then other instrumental parameters can be determined. For example:

- the random errors that determine the precision or repeatability of readings;
- the sensitivity of the instrument or how little can it 'see' or what is its detection limit'
- the specificity or how does the presence of other airborne contaminants affect the performance of the instrument? Do they 'interfere' and, if so, in a 'positive' or 'negative' manner?
- the stability of the instrument, i.e. to what extent is it subject to zero or span drift, and therefore how long is a given calibration reliable? Once again, there may be a difference, from the conditions that exist in your office to those that occur on the shop floor.

How often does equipment have to be calibrated? Clearly, there is a trade-off between the costs (time, and consumables) of calibration, and the consequences

of being 'wrong'. This relates back to the 'why' of performing the evaluations in the first place. Is any one test part of an ongoing surveillance program that consistently shows exposures at < 5% of TLV®? Is it to determine whether a particular substance is present in the air, and therefore a specific statutory obligation is invoked? Is it to compare two different modes of operating existing engineering controls or to decide whether to spend $500,000 on a new ventilation system?

The predominant concern, of course, has to be that erroneous results may have tragic consequences, e.g., a worker entering a confined space being overcome by toxic vapours or inappropriate hot work (welding) triggering an explosion. There could be substantial personal and financial factors involved, both in terms of the immediate occurrence and any subsequent litigation. We can think of the whole issue in these cases in terms of the Decisional Import of the Results (DIR), i.e. what depends on the results?

Even authorities can fall into the trap of reporting values that would appear to be the result of instrument inaccuracy. In a recent review text, an article on air quality in office buildings[4] indicates rooftop carbon dioxide levels (determined by Miran 1A direct reading infra-red spectrophotometer) as low as 80–150 ppm (over a period of several days). The authors indicate that the instrument was calibrated; we would welcome rationale, other than miscalibration, for the findings.

Direct-Reading Tubes

To begin our consideration of specific devices that require calibration, let's look at what is surely the simplest dynamic (as opposed to passive) hygiene monitoring device. That is, the direct reading (D/R) indicator tube pump. Drager, Gastec, MSA and Kitagawa are probably the four most popular manufacturers. These devices are designed to draw 100-mL volumes of air through pretreated 'detector' tubes. These then typically show a 'length-of-strain' proportional to the concentration of the contaminant of interest, and you read off the scale at the stain interface. What could possibly go wrong?

Melvin First recently wrote:[5]

> Although it is generally assumed by those ignorant of industrial hygiene theory and practice that indicator tubes can be used by unskilled personnel for monitoring work environments, it has been repeatedly demonstrated in practice that serious errors in sampler operation, in selection of sam-

> pling locations and times, and in interpretation of results occur unless the tubes are in the hands of a trained operator who is closely supervised by a competent professional.

. . . and suggested that . . .

> checking a suitable sample of each batch of tubes purchased is considered essential. Rechecking after a period equivalent to a large fraction of the normal shelf-life is prudent.

In the hands of the professional, direct reading indicator tubes are a useful and even essential component in the arsenal of devices used to evaluate the workplace environment. However, we use them as a 'quick-and-dirty' method. Some tubes are highly accurate and precise, whereas other types (even by the same manufacturer) suffer from systematic errors or deficiencies in stain development, which lead to inconsistent readings. Generally, they are not equivalent to the official methods and, therefore, are used as a screen and not as a definitive indicator of exposure. However, particularly for contaminants such as carbon monoxide (which do not have recent 'official methods'), increasing use is being made of long-term detector tubes as dosimeters (in addition to the use of data logging D/R instruments).

When we use direct tubes, we must be fully aware of their limitations and refer to the manufacturer's specification sheet for interference data, etc. The limitations of these tubes have been described in detail in the standard texts, but, clearly, these are not widely read by the users of D/R tubes.

In an assessment we were conducting at one facility, the occupational health and safety manager was very pleased to report (and we were amazed to hear) that they could typically not detect *any* ethylene oxide (EtO) exposures in their sterilization operations. We reviewed their monitoring program. They were using Gastec 163L tubes. Although it is common practice to store D/R tubes under refrigeration (to minimize thermal degradation), these tubes specifically require it. This facility did not refrigerate their D/R tubes. Not only that, but they were using tubes past their expiry date. To top it all off, the person doing the testing had been 'trained' incorrectly. This tube requires two pump-strokes (i.e. 200 mL sample volume). Training had involved showing the tester to take one pump stroke, count off a few seconds, then release the pump plunger and draw a second sample. (The manufacturer's 'spec' for sampling time is two minutes per pump stroke, i.e.

even if the tube calibration had been accurate, the results would have been approximately 50 per cent low.) Once the tester had been shown how to use the pump correctly, a 'side-by-side' comparison was conducted between 'their' (expired) tubes and 'our' (current) tubes. Whereas we were picking up around 90 ppm at this particular phase of the operation, their tubes only registered 5 ppm. Clearly, these same tubes would have read even lower, according to how the pump had been used previously. In a later phase of the process, their tubes failed to detect *any* EtO (BDL <0.5 ppm), whereas ours showed a 9 ppm level (OEL−TWA = 1 ppm)!

With any D/R pump, a leak may occur in the system as a result of the failure of one or more components. Any leak will lead to lowered values. Therefore, if you are to collect reliable data, you must conduct a 'leak check' as a minimum. Insert one end of a sealed tube into the pump and draw one volume of air (one piston stroke, or 'squeeze', depending on the type of pump). After a minute (or 30 minutes is more desirable according to Leichnitz[6]) verify that air has *not* flowed into the evacuated chamber (i.e. piston pump reverts to within 6 mm of the closed position when unlocked and *gently* released and guided back; bellows pump remains fully compressed). You should at all times be confident that your pump is not leaking. To achieve this level of confidence, and depending on the testing that you are doing, you might want to perform this check before each set of determinations or on a daily to weekly basis.

In addition to this, you should check the actual *volume* of air drawn, upon receipt of a new pump, and then, periodically (Gastec recommends that it be done after each lubrication). The setup is the same as that used to calibrate personal sampling pumps: inverted burette and beaker containing soap solution. We once received a pump that consistently drew about 90 mL of air rather than 100, which would, of course, have made all the readings low.

There could be many reasons why you might want to calibrate the tubes themselves:

- Verify manufacturer accuracy (the commonly-cited 25 per cent figure is all right as far as rules-of-thumb go, but is by no means a firm rule; for example, the Gastec mercury tube at least used to (1982) read 50 per cent low at 10X TLV®).[7]
- Verify that tube integrity was maintained during shipment and storage.

- Verify tube accuracy under 'real-world' conditions (actual temperature, humidity and interferences at worksite).
- Determine the precision of the tubes to incorporate into statistical considerations, e.g. Drager advises that its methyl acrylate 5/a tube has a relative standard deviation of 30-40 per cent.

However, for most readers, tube calibration would be impractical, and it would be acceptable to use tubes directly as received from the supplier. Once again, though, you should be aware of these factors and vigilant for the development of any of these problems.

Personal Sampling Pumps

In the determination of worker exposures, most 'official methods' (such as those prepared by NIOSH or provincial regulatory agencies) call for the use of personal sampling pumps to draw air through a sampling matrix (e.g. charcoal tube or filter), which is subsequently analysed in the lab. The *analytical* reliability of the final result hinges both on the work done by the chemists in the lab (which provides a measure of the *mass* of contaminant collected) and on the accuracy to which the sample air volumes are known. Mass of analyte divided by air volume provides the airborne concentration of the contaminant. Air volumes are determined by the personnel doing the air sampling in a similar fashion as reported for D/R pumps. The 'classic' method for determining flow rate is the bubble burette, although a variety of electronically-facilitated devices are now available, as are 'mass flow' instruments (based on thermal principles). Many pumps have a 'rotameter', but this by itself is not sufficiently accurate to use as a measure of flow rate.

The Ontario codes for air sampling (attached to the DSRs) call for a pump flow rate that does not deviate by more than $\pm 5\%$ from that prescribed. This is to be verified by calibrated flow meter (rotameter) or constant flow mechanism. Most pumps sold these days are 'constant flow' pumps, meaning that there is some electronic feedback loop to gauge actual flow and adjust motor speed accordingly. This has greatly facilitated the maintenance of precise pump flow rates and, hence, accurate air sample volumes. However, there is still a need both for 'leak-testing' to verify the integrity of the sampling train and for pump calibration. Both should be conducted on the full 'sampling train'.

The Ontario Code methods call for calibration after:

- 40 hours
- harsh treatment
- disassembly

However, it is good practice to verify flow rates pre- and post-sampling (similarly to what is required in the CSA standards for the evaluation of noise levels/exposures.[9] The NIOSH methods also recommend that pumps be calibrated with each use.[10]

An earlier review[7] of mercury exposures in academic and clinical environments offered the following critique of the calibration requirements:

> The factors of accuracy and precision required in a Code for Air Sampling and the associated functional parameters (pump flow, etc.) may be inappropriate or inconsistent. Temperature is to be determined to ±1°C and barometric pressure to ±5 mm Hg, i.e. possible errors of magnitude of 1/273 and 5/760, or 0.3 per cent and 0.6 per cent respectively are to be considered at this point. The pump flow rate deviation is not to exceed ±5%, yet calibration need not be conducted more frequently than every 40 hours (e.g. after 20 two-hour samples). Analysis of mercury standards in the MOL lab (at microgram levels equivalent to no more than half the TWAEL) produced relative standard deviations of two to three per cent. According to the equivalency clause (section 17), methods and procedures may vary from the Code only if their accuracy and precision match, or exceed, those stipulated. Certainly, the accuracy of any determination needs be known, but this is best left to professional interpretation. The approach taken . . . has resulted in something that is too much of a 'numbers game' and introduces into the determination of occupational health risks a false impression of accuracy.
>
> The suggestion that accurate analysis of mercury vapour levels to within a few percent is *essential*, assumes that a mercury vapour level of 0.045 mg/m^3 is somehow significantly less toxic than a level of, say, 0.05 mg/m^3, or even that a mercury vapour level of, say, 0.02 mg/m^3 will be equally toxic to all individuals.
>
> Certainly, at least as important as the accurate analysis of the sample is the requirement that it be, in fact, representative of the worker's

breathing zone concentration, and that *all* areas with elevated mercury levels be identified.

Although we are concerned here with pump 'calibration' in terms of making certain instrument adjustments (and documenting what we do), remember that in a broader sense the term has to do with overall 'quality' of measurement. Hygiene equipment, even if well calibrated, can give the 'wrong' answers if the 'right' questions aren't put to it. The results conveyed by the sampling will not address the risks to a specific worker's health if we are not sampling air that is representative of the air actually inhaled by the worker. In fact, we often attempt to sample under what are known as worst-case conditions, because if these produce acceptable results, then a wider range of issues is resolved. In addition to correctly answering the 'where' and 'when' questions, the 'what' question (like so many other variables) involves a judgement call.

Someone is working with hot plastic and is complaining of eye irritation and nosebleeds. You want to do air sampling to see if that person is over-exposed to any specific contaminants. Before you can do any sampling, you need to know *what* you're looking for in order to select the appropriate sampling matrix, flow rate, analytical procedure, etc. Common practice might involve sampling for the ingredients specified on the MSDS. Especially in the case of a 'thermal degradation' issue, this would likely answer the wrong question and may well do a disservice to the worker with the complaint.

In addition to the technical considerations regarding calibration, etc., there are the more judgemental concerns. These should be resolved by someone who *understands* the environmental concerns and their potential impact on health as well as the uses and limitations of the device(s) utilized to assess the workplace environment.

Pump calibration then involves the following steps:

- determine sampling train required
- determine flow rate required
- adjust pump to approximate flow rate
- assemble sampling train
- verify absence of leaks (i.e. all air drawn by pump flows *through* sampling matrix)
- determine flow rate (and adjust if necessary)
- conduct air sampling
- determine flow rate post-sampling and compare to

pre-value . . . (five per cent deviation is commonly cited as criterion to nullify sample)
- document above and keep with analytical results

Direct-Reading Instruments

So far, we have discussed detector tubes and sampling pumps. There are a variety of reasons why we might also want to use D/R *instruments*:

- fast response (real-time)
- wide range (quali- and/or quanti- tatively)
- official method (e.g. for O_2)
- lower cost of expendables

Clearly, D/R instruments are convenient and, in many applications (e.g. confined-space entry), indispensible. The cautions we have been describing certainly apply here as well. Although many instruments have a built-in 'span' check this should also be verified with an independent source (i.e. 'cal'-for calibration-gas). Calibration involves the detector, but the 'analyser' function may also be calibrated, i.e. the effect of interference.

As a rule of thumb, it is good advice to read and to follow the manufacturer's instruction manual. The manufacturer *should* know more about the instrument than anyone else. However, there at times appears to be a conflict between the technical and the marketing staffs at the manufacturer's level. Technical personnel want the users to understand the instrument and to use it with a knowledge of its limitations. On the other hand, marketing wants to sell the instrument, and therefore may 'simplify' some technical matters.

One supplier of a CO_2 monitor, in the manual relating to an older (pre 1989) model, recommends that if nitrogen is not available, 'normal air' be assumed to be 300 ppm CO_2 for the purposes of zeroing the instrument.[11] This approach will likely cause the subsequent readings to be 'low'.

Similarly, the prototype gold film instrument for mercury (Jerome 401) experienced decremental sensitivity with use; this factor was not communicated in the manufacturer's literature. However, this problem appears to be resolved in the current Model 411.

An infra-red spectrophotometer with a built-in calibration library for 106 gases/vapours (Miran 1B2) is both sophisticated and simple to operate. Once again, it is easy to obtain results that lead to the wrong conclusions. For formaldehyde, OELs are typically 1 ppm, but as an index of Indoor Air Quality (IAQ), 0.1 ppm is commonly used as a criterion. When used in accor-

dance with manufacturer recommendations, this spectrophotometer can readily provide values of 0.6 ppm formaldehyde in an environment where official methods provide values below 0.1 ppm. This discrepancy is due to interferences. As well, if the instrument is 'zeroed' in air presumed to be 'clean', but that in fact contains the contaminant of interest, then subsequent readings will be low.

How, then, do you go about using D/R instruments with confidence? Once again, you need to know your instrument. The ACGIH Air Sampling Instruments text (6th ed.[12] — The 7th edition is to be available in Feb. 1990) expresses this as:

> The tendency of the unwary and inexperienced user is to believe the manufacturer's calibration, and this often leads to grief and error. Any instrument with calibration adjustment screws should, of course, be suspect, since such adjustments can easily be changed intentionally or accidentally, as in shipment.
>
> All instruments should be checked against appropriate calibration standard atmospheres immediately upon receipt and periodically thereafter.

In consideration of the purchase of an instrument, one factor clearly is the ease and cost of calibration. At the same time, you should make sure that the 'calibration' controls are not readily altered 'inadvertently'. Some otherwise excellent instruments suffer from this problem. These controls should be at least recessed or behind a panel that normally remains closed.

You need to verify (at *minimum*) a 'zero' and a 'cal' set point. You would then often assume that readings in between the two were accurate, tempered by any manufacturer's information available. This would include an examination of interference data. For example, one monitor for carbon monoxide was cited by the manufacturer[13] as having an equivalent response to ethanol. Ideally, you could calibrate every instrument in workplace air (using the Method of Constant Additions) to eliminate the effect of interferences. Once again, this would be impractical for most applications.

Conclusion

Individuals charged with the responsibility for conducting hygiene measurements are entrusted with the task of providing data that can have great significance in terms of worker health. Related to this, there may be legal

and financial liability. The manner in which these data are collected and reported should be consistent with their importance.

Résumé

Cet article traite des principes d'étalonnage permettant de déterminer la quantité des contaminants présents dans l'air sur le lieu de travail. Plusieurs sources sont citées, en plus d'informations issues de l'expérience personnelle de l'auteur, notamment en ce qui concerne le manque de précision des appareils de mesure. Les problèmes qui en résultent sont abordés en fonction de l'importance des erreurs potentielles.

Acknowledgements

The author expresses his gratitude to: M-A Boyd and G. Hetherington for their dexterous and diligent word-processing; T. Beardall for his critical review of the manuscript; OH&S Canada for originally requesting the paper, and for now permitting the full text to be published in OHIO; G. Rajhans for soliciting its submission to OHIO; the Occupational Health Centre for providing the experiential base for much of the material; the MOL for its support of the centre; his family for tolerating the 'spare time' taken up by such activities.

References

[1] Ontario Working Exposure Guidelines for Chemical and Biological Agents. Occup Health in Ont 1989; 10(4):211-214.

[2] Toronto Star. December 1986.

[3] Occupational Health Centre at Queen's University; unpublished field data.

[4] Sterling EM, *et al*, 1987. Field Measurements for Air Quality in Office Buildings . . . pp 46–65. *In*: Taylor, JK (ed): Sampling and Calibration for Atmospheric Measurements. ASTM.

[5] First MW. Sampling and Analysis of Air Contaminants: An Overview. Appl Ind Hyg 1988; *3(12)*: F-20-F-27.

[6]Leichnitz K. Detector Tube Measuring Techniques. Ecomed FDR 1983.

[7] Bickis UI. Mercury: An Evaluation of Academic and Clinical Use: Exposures and Controls, U. of T. (M.Eng. thesis) 1984.

[8] Detector Tube Handbook, 5th ed. 1983. Dragerwerk AG.

[9] CSA, 1986. Procedures for the Measurement of Occupational Noise Exposure. CAN/SCA-Z107.56-M86.

[10] NIOSH, 1984 (as updated to 1989.05.15). Manual of Analytical Methods 3rd ed.

[11] Instruction Manual for Model R1-411 Infrared Co_2 Indicator. Gastech Instruments Canada Ltd. (pre-1989).

[12] ACGIH. 1983. Air Sampling Instruments. 6th ed.

[13] COMPUR Monitox 4100S for CO: cross-sensitivities.

Book Review

Ontario Health and Safety Law

Norman Keith

Published by Canada Law Book Inc., Aurora, 1989

For a subject area that has grown increasingly complex and that has received much professional and media attention in the past few years, the complete lack of a comprehensive text on occupational health and safety law in Ontario until now is surprising. Employers, trade unions, and professionals working in the area of health and safety will know what a difficult task it has been to obtain written legal interpretations and case law to assist them in this rapidly changing area.

Norman Keith, in his text *Ontario Health and Safety Law*, has gone a long way towards filling this gap with his comprehensive and detailed review of the case law and legislation in Ontario. The text is packaged as a how-to manual for employers, trade unions and others who must interpret and administer the legislation on a day-to-day basis.

The text commences with a historical overview of the development of health and safety laws in the province. It goes on to outline the duties of employers and other workplace parties under the Act and regulations, including general duties, duties respecting hazardous products under the Workplace Hazardous Materials Information System (WHMIS) and duties relating to the introduction of new biological or chemical agents in the workplace. Along with this thorough review of duties under the legislation, examples of prosecution cases that illustrate the principles have been included.

The text includes a chapter on the powers of Ministry of Labour inspectors and the types of orders available as well as a comprehensive chapter on the appeal of Ministry of Labour orders. Other chapters review the law relating to the right to refuse work, the process of investigations and inquests by coroners after a workplace fatality and the process involved in prosecutions under the Act. A detailed, clause-by-clause overview of the provisions of Bill 208 is included with the text.

The overwhelming strength of this text is its unique role in compiling case law from prosecutions, appeals of orders, and complaints before the Labour Relations Board in a detailed manner for the first time in On-

tario. Many of the cases referred to are decisions that are not currently available in reported form from any other source. Clearly, a tremendous effort was made by the author to obtain these unreported and sometimes obscure decisions for inclusion in the text.

As a practitioner in the health and safety area, this writer found that the practical side of the text, particularly the chapter on improving workplace health and safety, could be bolstered by providing practical examples, or more 'how to' information, in addition to the general information that is provided. However, the manual format of the text ought to permit its expansion to incorporate further practical information and suggestions for dealing with health and safety problems and issues.

In conclusion, this text contains a thorough overview of the legislative provisions and the case law relating to health and safety in Ontario. As a unique source of previously unpublished case law, it is sure to be regarded for years to come as an important resource tool for lawyers and professionals in this area.

Cheryl A. Edwards

Recent Publications Available from the Government Book Store

Support Literature

- Workplace Hazardous Materials Information System (WHMIS): A Guide to the Legislation
- Factors Modifying Lung Cancer Risk in Ontario Uranium Miners
- Waste Anaesthetic Gas Exposure in Veterinary Hospitals — Hazard Alert
- Policy and Guidelines in Dealing with AIDS and HIV Infections
- Regulating Hazardous Substances in the Workplace — Joint Steering Committee pamphlet
- Occupational Health and Safety Act — Interpretation and Opinions
- Mortality among Employees of Atlas Specialty Steels
- Mortality among Employees of Celanese Canada
- Biotechnology in Ontario — Growing Safely
- A Guide to Ontario's Workplace Smoking Law (brochure)

The 15th and 16th Semi-Annual Intensive Workshops in Industrial Hygiene. University of Toronto

Monday, April 23, 1990 to Friday, April 27, 1990

and

Monday, September 24, 1990 to Friday, September 28, 1990

These workshops are designed for those who, for the following reasons, would benefit by taking the course:

— To increase knowledge of their specialization in occupational hygiene;
— feel the need for a general refresher course;
— for recent entrants to the hygiene field who wish to broaden their background knowledge of occupational hygiene

The panel of lecturers includes Dr. John Steel, Dip.Occ.Hyg., from the Department of Occupational Health and Hygiene, Medical School, University of Newcastle-upon-Tyne, United Kingdom, personnel from the Ontario Ministry of Labour, and faculty and staff of the University of Toronto. The expertise of the speakers covers all relevant aspects of hygiene, risk assessment, human factors engineering, toxicology, occupational medicine and occupational health and safety legislation. A hands-on equipment demonstration and monitoring round-table are included in the workshop.

The Industrial Hygiene and Hazard Control Engineering Program of the University of Toronto presents the workshops bi-annually. Professor J.W. Smith, Ph.D., C.Eng., C.I.H., chairman of the Department of Chemical Engineering and Applied Chemistry is the program co-ordinator.

Enquiries should be addressed to:

Julie Mendonça
Department of Chemical Engineering
and Applied Chemistry,
University of Toronto,
Toronto, Ontario
M5S 1A4
(416) 978-6615

Coming Events

April 22–24, 1990	Toxico — An Environmental Priority. TORONTO, ONTARIO, CANADA. For further information, contact: Dr. H.G. McAdie, H.G. McAdie Associates, Suite 300, 290 Lawrence Avenue West, Toronto, Ontario, M5M 1B3. Telephone: (416) 785-7218, FAX: (416) 785-7217.
April 24–26, 1990	International Indoor Air Quality and Ventilation in Warm Climates. LISBON, PORTUGAL. For further information, contact: Secretariat — IIAQVC, International Indoor Air Quality and Ventilation Conference, British Occupational Hygiene Society, 1 St. Andrews Place, Regents Park, London, England, NW1 4LB. Telephone: 01 823 9401.
April 24–27, 1990	Occupational Health Nurses Association of Nova Scotia — Conference '90: Skills Plus. HALIFAX, N.S. For further information, contact: G. Thomas, Telephone: (902) 424-5400.
May 6–11, 1990	XII World Congress on Occupational Safety and Health. HAMBURG, FRG. For further information, contact: Hamburg Messe und Congress GmbH, Postbox 302480, D-2000 Hamburg 36, Federal Republic of Germany.
May 13–18, 1990	American Industrial Hygiene Conference. ORLANDO, FLORIDA. For further information, contact: AIHA, 475 Wolf Ledges Parkway, Akron, OH, 44311-1087, Telephone: (216) 762-7294.
May 17–19, 1990	Ninth International symposium on contact dermatitis. STOCKHOLM, SWEDEN. For further information, contact: Professor Jan E. Wahlberg, Contact Dermatitis, 1190, Karolinska Hospital, S-104 01 Stockholm, Sweden.

May 20–23, 1990	FUTURESCOPE 90, GOLD COAST, AUSTRALIA. For further information, contact: National Safety Council of Australia Congress and Exposition, C/-Pacific Rim CONVENTION Systems Pty. Ltd., G.P.O. Box 853, Brisbane, Qld., Australia, 4001. Telephone: 07/221 2762, FAX: 07/220 0231.
May 20–24, 1990	World Conference on Lung Disease. BOSTON, MASSACHUSETTS, U.S.A. For further information, contact: NIOSH/OPPE, Bldg. 1, Rm 3040, Mailstrop D29, U.S.A.
June 12–15, 1990	The Twenty-First National Meeting on Occupational Medicine. ROUEN, FRANCE. For further information, contact: Dr. Alain Poirier, President, or Dr. M. Gournay or Dr. M. Monfrin, Vice-Presidents: Comité d'Organisation des XXIèmes Journées Nationales de Médecine du Travail, 22, rue Guy de Maupassant, BP 538, 76005 Rouen Cédex. Telephone: 35.71.85.90.
June 19–23, 1990	6th International Conference on AIDS. SAN FRANCISCO, CALIFORNIA, U.S.A. For further information, contact: c/o NIOSH/OPPE, Building 1, Room 3040, Mailstrop D29, U.S.A.
July 2–6, 1990	Society of Occupational Medicine. EDINBURGH, U.K. For further information, contact: SOM, 6 St. Andrew's Place, Regents Park, London, England, NW1 4LB. Telephone: 01 486 2641.
July 29–August 3, 1990	5th International Conference on Indoor Air Quality and Climate. TORONTO, ONTARIO, CANADA. For further information, contact: Centre for Indoor Air Quality Research, University of Toronto, 223 College St., Toronto, Ontario, M5T 1R4.
August 12–16, 1990	Human Aspects of Advanced Manufacturing and Hybrid Automation. HAWAII, U.S.A. For further information, contact: Hilton Hawaiian Village, Honolulu, Hawaii, U.S.A.
August 14–19, 1990	14th Symposium — International Committee on Food Microbiology and Hygiene. NORWAY. For further information, contact: Food Micro '90, Matforsk, Norwegian Food Research Institute, Oslo 1, N — 1430 As, Norway.

September 10–14, 1990	Minesafe International 1990. PERTH, WESTERN AUSTRALIA. For further information, contact: The Secretary, The Chamber of Mines and Energy of Western Australia (Inc.), 7th Floor, 12 St. George's Terrace, Perth, Australia, 6000. Telephone: (09) 325 2955, FAX: (09) 325 4562, Telex AA92792.
September 16–20, 1990	Ventilation '91, 3rd International Symposium on Ventilation for Contaminant Control. CINCINNATI, OHIO, U.S.A. For further information, contact: Ventilation '91, c/o ACGIH, 6500 Glenway Avenue, Building D-7, Cincinnati, Ohio, U.S.A. 45211-4438. Tel: William Kelley (513) 661-7881.
September 22–28, 1990	23rd International Congress on Occupational Health. MONTREAL, QUEBEC, CANADA. For further information, contact: Dr. M. Lesage, Chairman of the Organizing Committee, 84 rue de Brésoles, Montréal, Québec, Canada, H2Y 1V5.
November 4–7, 1990	Strategies in Occupational Hygiene and Environmental Protection. MILAN, ITALY. For further information, contact: AIDII, Via Clefi 9, 20146 Milan, Italy.
December 2–5, 1990	Australian Institute of Occupational Hygienists Conference 1990. PERTH, WESTERN AUSTRALIA. For further information, contact: c/o Government Chemical Laboratories, William St., Brisbane, Queensland, Australia 4000.
March 4–7, 1991	Toxic Metal Compounds (interrelation between chemistry and biology). LES DIABLERETS, SWITZERLAND. For further information, contact: Dr. Ernest Merian, Im Kirsgarten 22, CH-4106 Therwill, Switzerland.

Ontario
Ministry of
Labour

Occupational
Health and Safety
Division

Health and Safety
Support Services
Branch

400 University Ave.
Toronto, Ontario
M7A 1T7

Telephone:
(416) 326-1402

ISSN 0705-9388